# Chapter 5. Zooplankton, 1997-2000

Mysid shrimp and zooplankton are important food sources for larval, juvenile, and small fish, such as delta smelt, juvenile salmon, striped bass, and small splittail. The zooplankton monitoring program seeks to determine the annual population level of *Neomysis mercedis*, and various zooplankton species or genera in order to assess the size of the food resource for fish. This monitoring also seeks to detect the presence of exotic species introduced to the estuary. The zooplankton study began in June 1968 to monitor *Neomysis mercedis*, and expanded in January 1972 to include copepods, cladocera, and rotifers.

## Methods

Zooplankton and mysid shrimp were sampled monthly at 15 to 20 stations in the upper San Francisco Estuary (Figure 5-1). Eighteen of these stations were at fixed locations and two stations were considered "floating" stations, which were located where the bottom electrical conductance was 2 and 6 mS/cm, respectively. One station (Station 325) in San Pablo Bay and two stations (Stations 2 and 4) in Carquinez Strait were sampled only when their surface salinity was less than 20 mS/cm. Station D41 in San Pablo Bay was sampled on every survey beginning in March 1998.

At each station, three types of sampling gear were deployed. These included: a large *Neomysis* net (1.48-m long and 29 cm in mouth diameter, mesh size of 0.505 mm) mounted on a towing frame made of steel tubing, with a General Oceanics flow meter at its mouth; a Clarke-Bumpus net for zooplankton (mouth diameter of 12.5 cm and a mesh size of 154 µm) mounted above the *Neomysis* net; and a 15 liter/minute-capacity pump. At each station, the towing frame was lowered to the bottom and retrieved obliquely in several steps over a 10-minute period. Zooplankton small enough to pass through the Clarke-Bumpus net (mostly copepod, nauplii, rotifers, and Oithonids) were sampled with the pump. At each station, the pump intake was lowered to the bottom, raised slowly to the surface, and then lowered and raised a second time. The pumped water was discharged into a 19-liter carboy, the carboy was shaken, and a 1.5 to 1.9 liter sample was then decanted into a jug. All samples were preserved in buffered 10% formalin and returned to the laboratory for identification. Surface temperature and specific conductance were both measured at the beginning of each tow, and surface specific conductance was measured at the end of each tow. Bottom specific conductance was measured using a Seabird (model CTD 911) where the surface specific conductance was >1 mS/cm.

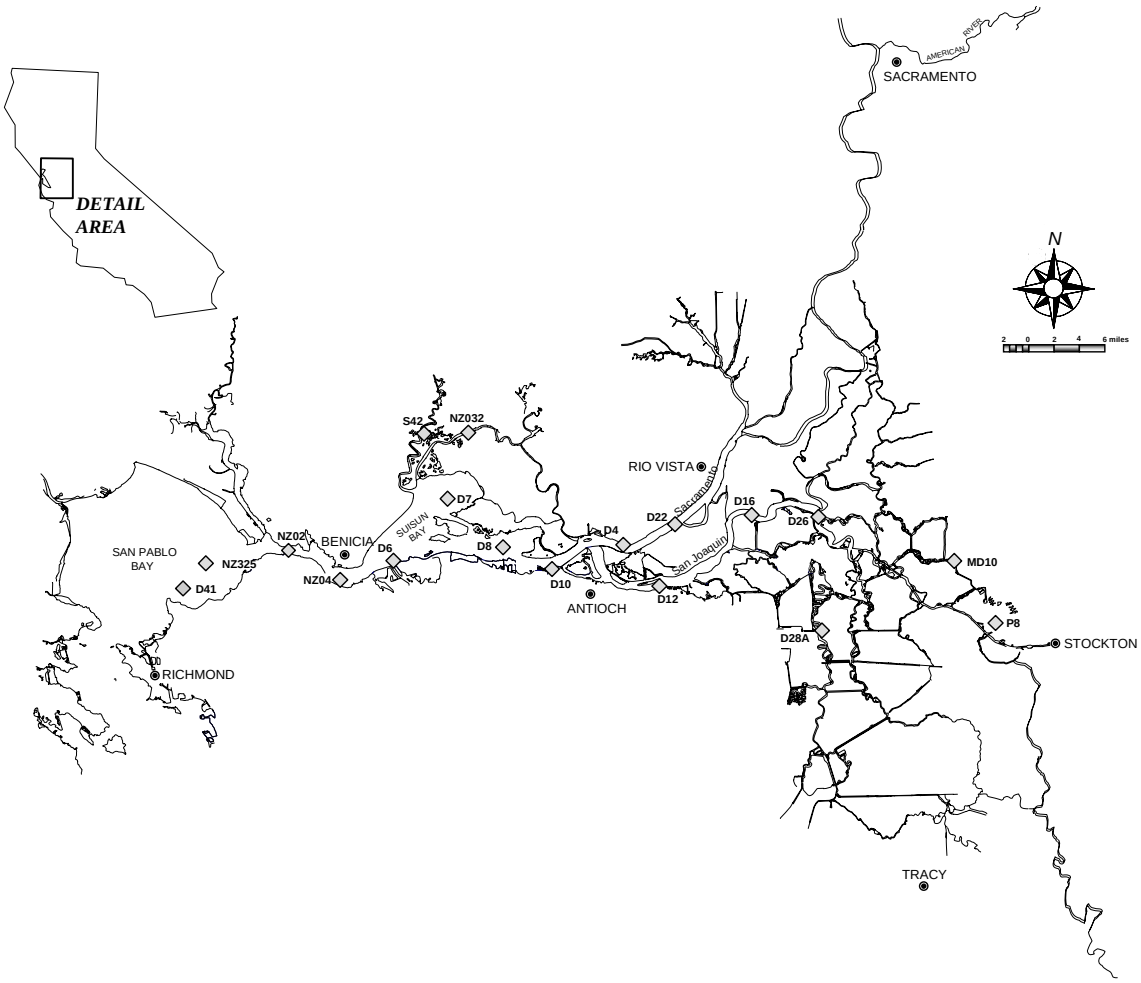


**Figure 5-1 Zooplankton monitoring stations**

To calculate monthly abundance indices, the sample area was divided into three zones based on bottom specific conductance. These zones were upstream of the entrapment zone (conductance <1.8 mS/cm); the entrapment zone (conductance from 1.8 mS/cm to 6.6 mS/cm); and downstream from the entrapment zone (conductance > 6.6 mS/cm). The density for each taxon was calculated as the number of organisms/$m^3$. Monthly abundance was calculated as the mean monthly density of each taxon in each zone. The number of stations in each zone varied month to month based on upstream and downstream shifts in the salinity gradient. Although no species was present at all stations in every month, averaging the density by the total number of stations sampled in each zone provided a common and consistent base for comparing taxon densities. Abundance data were log transformed ($\log_{10}$(abundance+1)) before plotting to improve interpretation by reducing month to month variability.

*Neomysis mercedis* has been identified and counted since 1968 and *Acanthomysis bowmani* since 1994. Identification and counting of the other five species of mysid shrimp caught by the Zooplankton Monitoring Project (*A. aspera, A. hwanhaiensis, A. macropsis*, *Deltamysis holmquistae*, and *N. kadiakensis*) began in 1998.

For brevity, the zooplankton were divided into the following four groups: calanoid copepods, cyclopoid copepods, cladocera, and rotifers. The trends of the three or four most abundant taxa in each group are presented.

# Results

The zooplankton and mysid shrimp findings for the 1997 through 2000 study period are summarized in Figures 5-2 through 5-6.

The mean densities of most taxa remained stable or increased throughout the 1997 to 2000 period. Only the calaniod copepod *Pseudodiaptomus forbesi* and the rotifer *Polyarthra* declined during 1997-2000 (Figure 5-3). The mean densities of the calanoid copepods *Acartia* and *Sinocalanus*, the cladocerans *Daphnia* and *Diaphanosoma,* and the cyclopoid copepod *Limnoithona tetraspina* increased slightly.

## Mysids

*Acanthomysis bowmani* was by far the most abundant mysid in all areas in 1997, 1999, and 2000 (Figure 5-2). In 1998, however, *A. bowmani* abundance was low. *A. bowmani* abundance was highest in the entrapment zone and downstream from the entrapment zone. Peak *A. bowmani* abundance occurred from May through October, except in 1998 when abundance peaked in April and May. In 1997 *A. bowmani* abundance outside the entrapment zone declined from 1996 levels, but increased thereafter.

*Neomysis mercedis,* the second most abundant mysid, was caught primarily in and upstream from the entrapment zone. Peak *N. mercedis* abundance in these areas occurred from April through June (Figure 5-2). Downstream from the entrapment zone, *N. mercedis* was found in small numbers only from February through July.

Identification and counting of *Neomysis kadiakensis* and *Acanthomysis aspera* began in 1998. *Neomysis kadiakensis*, the third most abundant mysid, was found primarily downstream from the entrapment zone, with few found within and upstream of the entrapment zone (Figure 5-2). Downstream from the entrapment zone, peak abundance came in April through May. A second peak was observed in November 2000. *Neomysis kadiakensis* was less abundant in 1999 than in 1998 and 2000.

*Acanthomysis aspera*, the fourth most abundant mysid, occurred almost exclusively downstream from the entrapment zone and was abundant only in 1998 and 2000 (Figure 5-2). Peak *A. aspera* abundance occurred in May of both years.

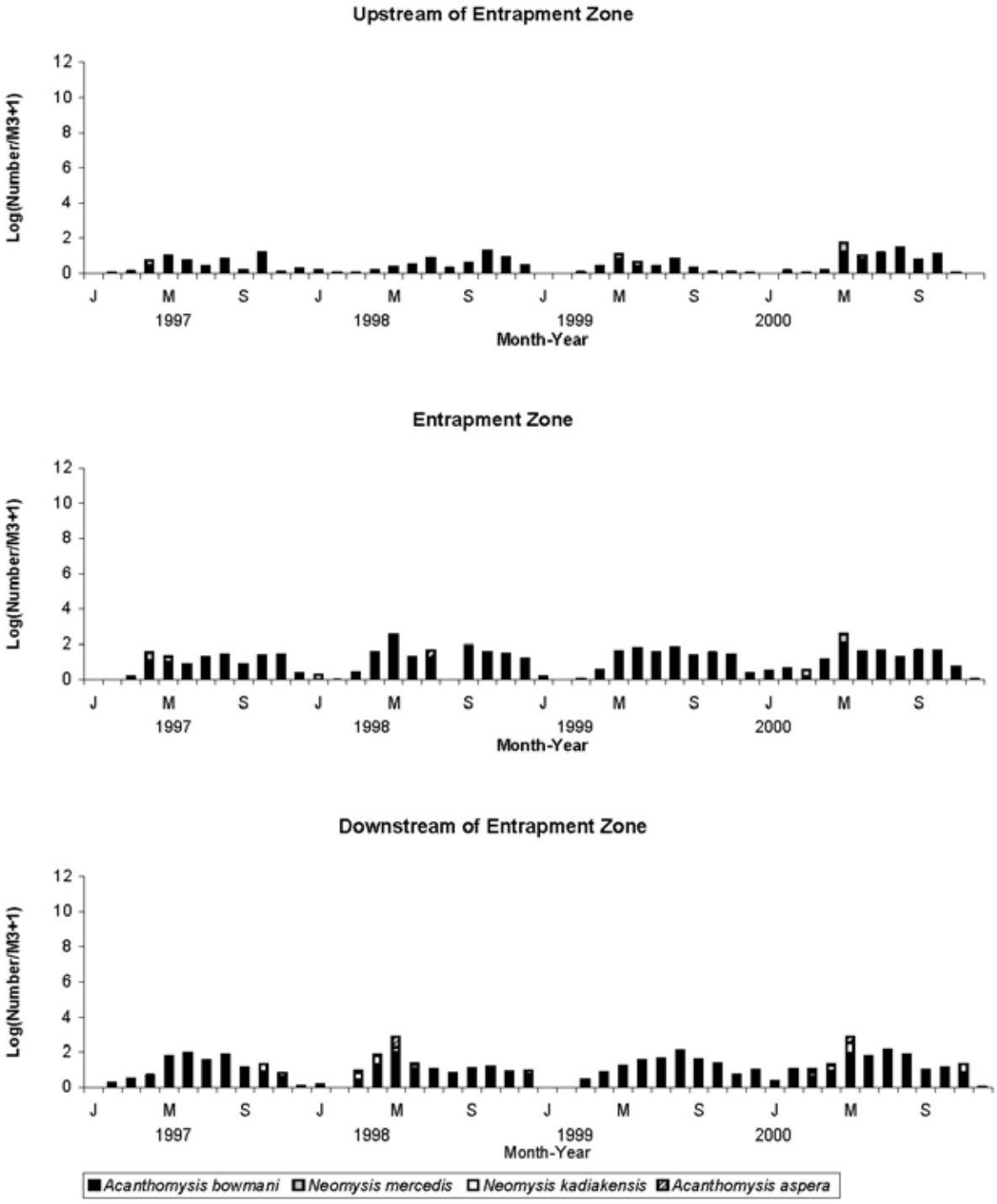


**Figure 5-2 Monthly mysid abundance upstream from, in, and downstream from the entrapment zone, 1997-2000**

## Calanoid Copepods

The introduced *Pseudodiaptomus forbesi* was the most abundant calanoid copepod in all areas in all four years except for downstream from the entrapment zone where *Acartia*, a native calanoid, was occasionally more abundant (Figure 5-3). *Pseudodiaptomus forbesi* abundance was greatest upstream of the entrapment zone and was almost as high in the entrapment zone. Peak *P. forbesi* abundance in all areas was from May through November. In 1999, the spring increase in abundance began in May, one to two months later than in the other years.

*Acartia* spp. was the second most abundant calanoid copepod and it occurred primarily downstream from the entrapment zone (Figure 5-3). Abundance downstream from the entrapment zone was high from January through June with peak abundance from March through June, minimal populations in September, and occasionally minimal populations as early as June and July. In 1997, *Acartia* abundance downstream from the entrapment zone was particularly low from June through September. *Acartia* spp. was also found sporadically from late fall through spring in the entrapment zone and upstream of the entrapment zone from late fall through spring.

The third most abundant calanoid copepod was the introduced *Sinocalanus doerrii* (Figure 5-3). The highest concentrations of this copepod were found upstream of and in the entrapment zone, although large numbers were also found downstream from the entrapment zone. Upstream of the entrapment zone, *S. doerrii* abundance peaked from April through September. In the entrapment zone, the abundance peaks occurred from March through July. The abundance peak downstream from the entrapment zone was from February through July.

*Eurytemora affinis*, probably an introduced species (Lee 2000), was the fourth most abundant calanoid copepod (Figure 5-3). Abundance was equally distributed across all three areas. Upstream of the entrapment zone and in the entrapment zone, *E. affinis* densities peaked between March and June. Downstream from the entrapment zone, abundance peaked from March through April, except in 1997 when the peak started in February. Densities were very low in the entrapment zone from August through September in all four years and upstream of the entrapment zone in all years except 2000.

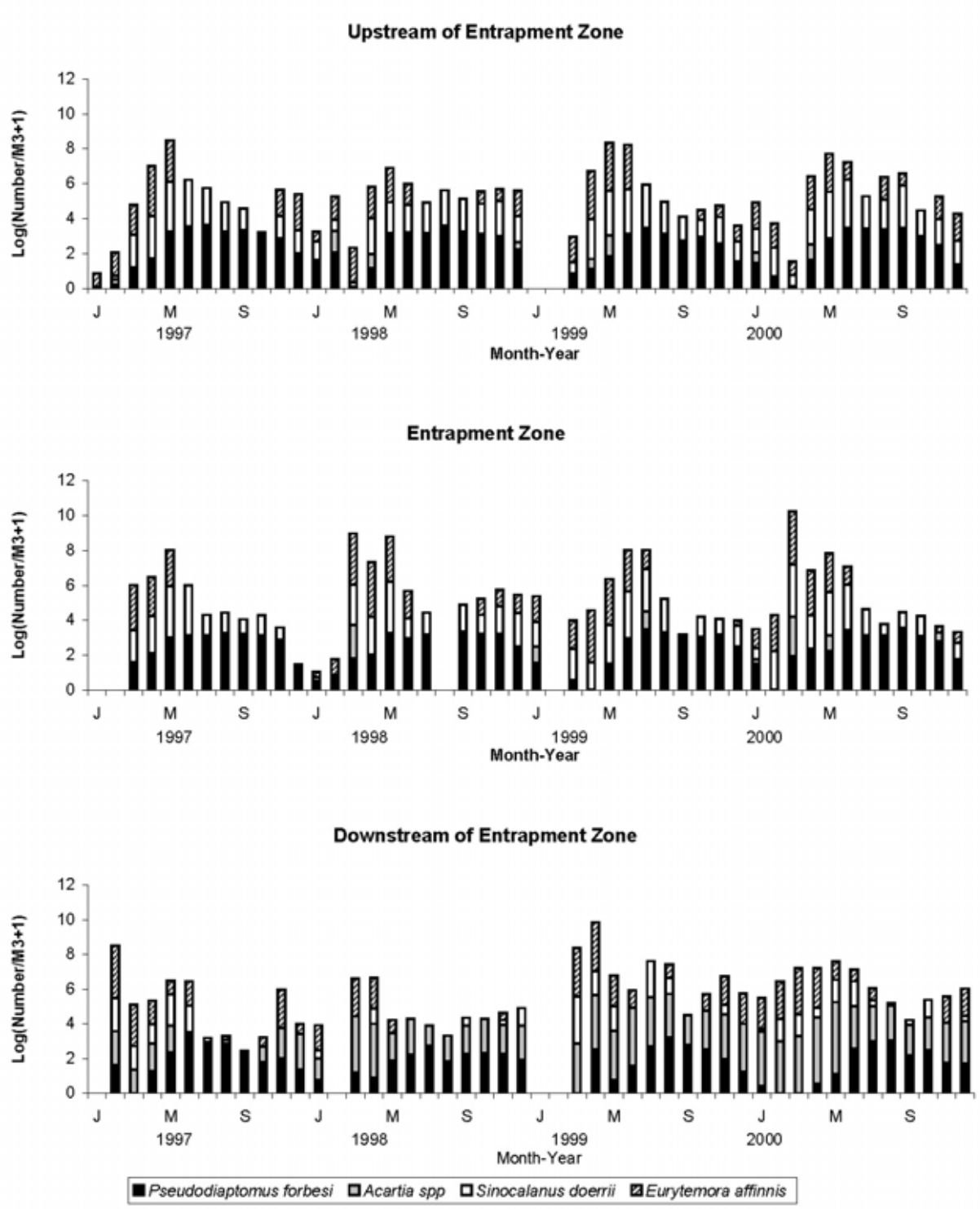


**Figure 5-3 Monthly calanoid abundance upstream from, in, and downstream from the entrapment zone, 1997-2000**

## Cyclopoid Copepods

*Limnoithona tetraspina*, introduced in 1994, was the most abundant cyclopoid copepod (Figure 5-4). *Limnoithona tetraspina* was abundant in all three areas but less abundant upstream of the entrapment zone than in the other two areas. Upstream of the entrapment zone, *L. tetraspina* had a peak abundance period from July through December. Beginning in 1998, a second period of high abundance occurred from March through May. By 2000, this second peak had become slightly higher than the late summer-fall peak. In the entrapment zone, *L. tetraspina* abundance peaked from April through November. Downstream from the entrapment zone, the abundance was more uniform throughout the year with a nominal April through October peak.

The native *Acanthocyclops vernalis* was the second most abundant cyclopoid copepod, and was abundant throughout the sampling area (Figure 5-4). *Acanthocyclops vernalis* was, however, less abundant downstream from the entrapment zone than in the other two areas. Its abundance peak was from February through July or August with a secondary peak in November, December, or November and December.

The introduced *Oithona davisae* was the third most abundant cyclopoid copepod and occurred primarily downstream from the entrapment zone (Figure 5-4). *Oithona davisae* was also abundant in the entrapment zone, and occurred sporadically upstream of the entrapment zone. Peak abundance occurred from August through February. Downstream from the entrapment zone, *O. davisae* abundance was characterized by a sharp dip in May.

## Cladocera

*Bosmina longirostris* was the most abundant cladoceran found from 1997 through 2000 (Figure 5-5). It was abundant throughout all four years upstream of the entrapment zone with a nominal peak from April through October. *Bosmina longirostris* was absent from the entrapment zone from July through October, but was present from January through June and in November and December in most years with the peak occurring from February through June. Its presence downstream from the entrapment zone was variable, with a nominal peak from February through June.

*Daphnia* spp., the second most abundant cladoceran, was most abundant upstream of the entrapment zone where its peak abundance occurred from February through September (Figure 5-5). In the entrapment zone and downstream, *Daphnia* spp. peaked from February through July. Its abundance downstream from the entrapment zone was lower and more variable than in the other areas.

*Diaphanosoma* spp., the least abundant of the identified cladocera, was found almost exclusively upstream of the entrapment zone (Figure 5-5). Peak abundance occurred from June through October.

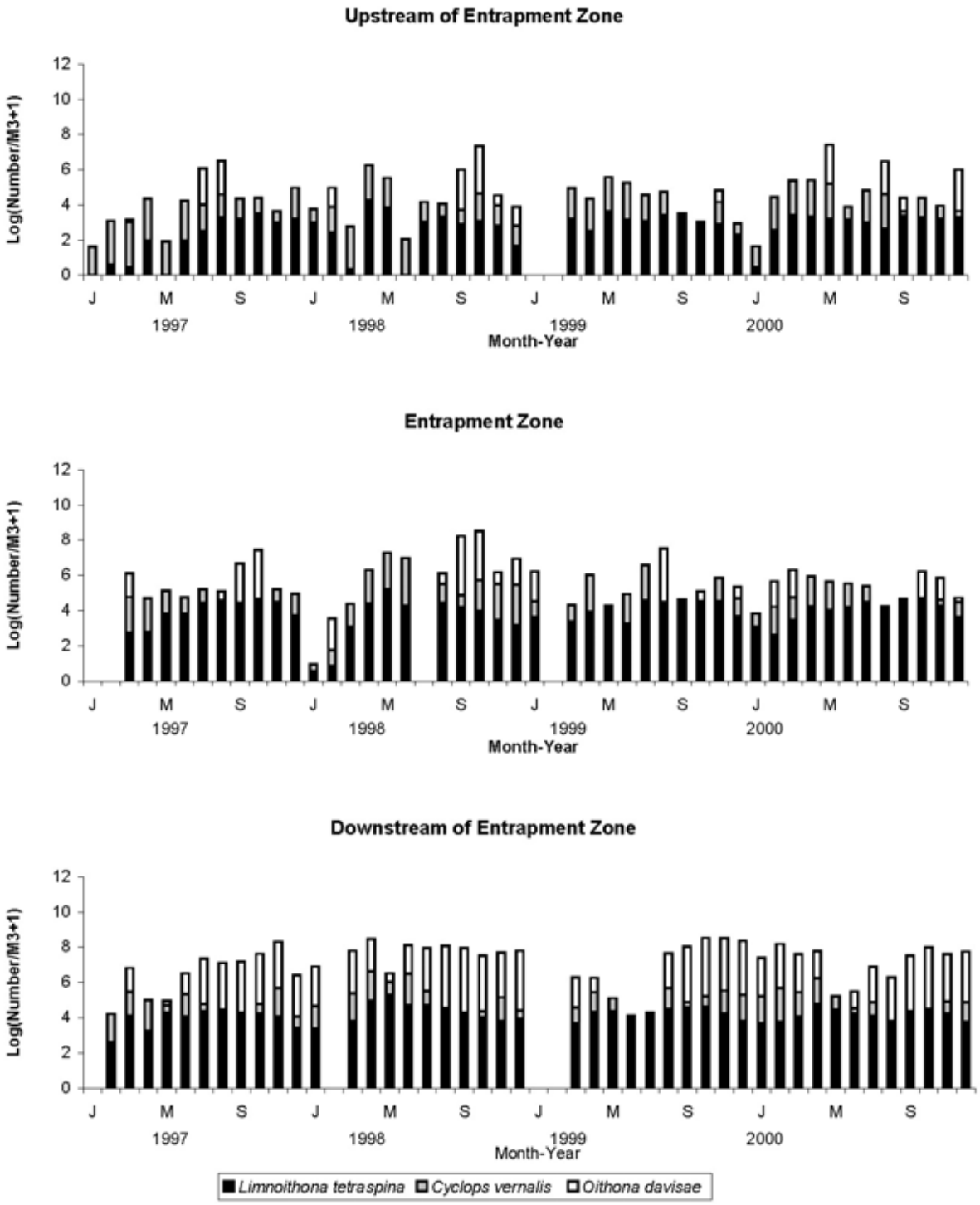


**Figure 5-4 Monthly cyclopoids abundance upstream from, in, and downstream from the entrapment zone, 1997-2000**

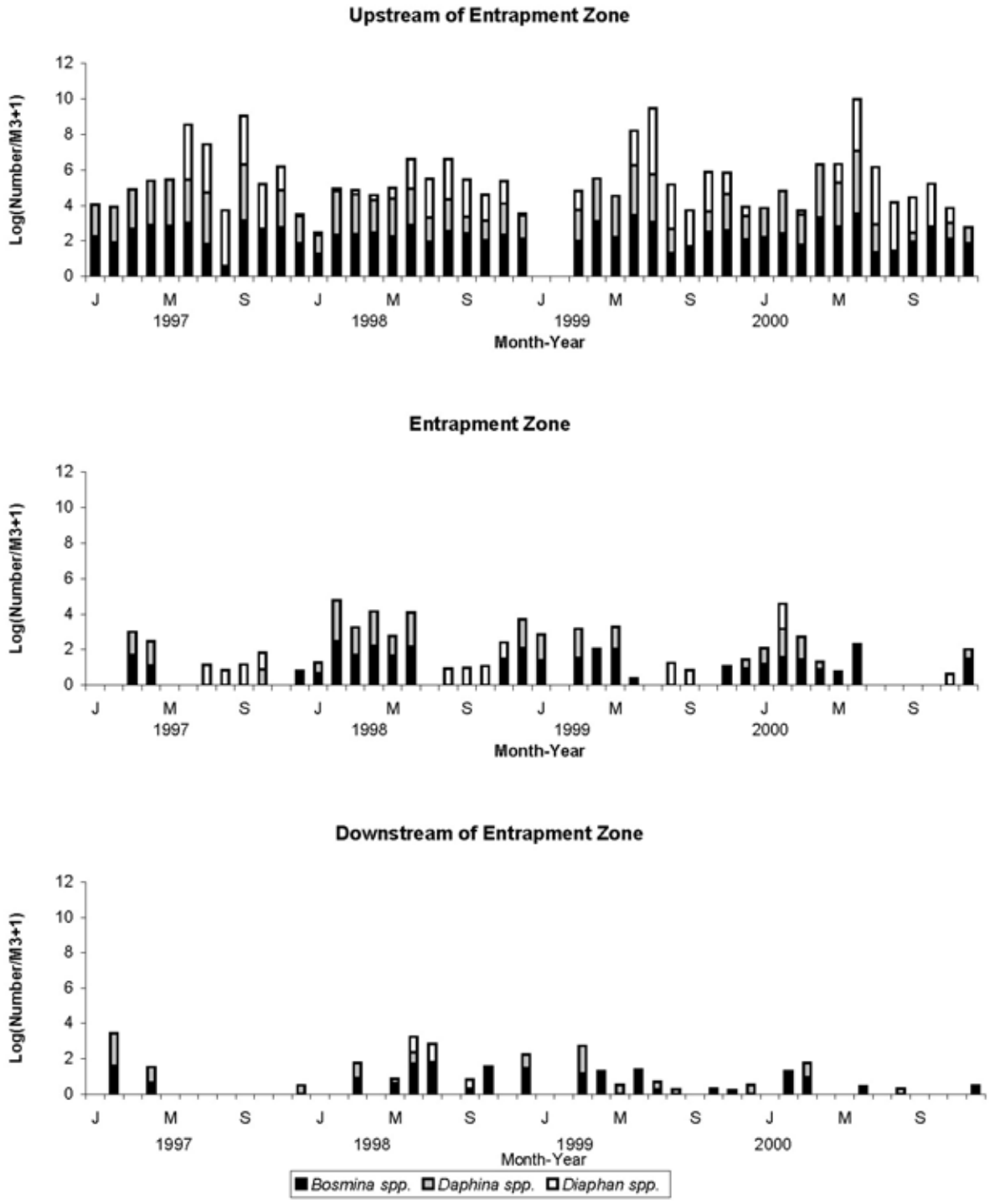


**Figure 5-5 Monthly cladocera abundance upstream from, in, and downstream from the entrapment zone, 1997-2000**

## Rotifers

The genus *Synchaeta* (not including *Synchaeta bicornis*) was the most abundant rotifer taxon (Figure 5-6). Although abundant in all areas, *Synchaeta* spp. was slightly more abundant upstream of the entrapment zone, with an abundance peak that began in October and continued through May of the following year. In the entrapment zone, abundance during the off peak period was lower than in the other areas.

The genus *Polyarthra* was the second most abundant rotifer and, except for sharp declines in June 1997 and 2000, its abundance upstream of the entrapment zone was roughly uniform throughout the year (Figure 5-6). In the entrapment zone, an abundance peak started in December and continued through May or June. Downstream from the entrapment zone, *Polyarthra* abundance was erratic, with a nominal peak from February through May.

The third most abundant rotifer taxon was the genus *Trichocerca* (Figure 5-6). The highest *Trichocerca* spp. abundance occurred downstream from the entrapment zone where there was a spring abundance peak from March through May, and a fall abundance peak from October through December for all four years. Upstream from the entrapment zone, *Trichocerca* abundance tended to be more uniform throughout the year with a nominal peak from January through July. Abundance was lowest in the entrapment zone where the two abundance peaks occurred in March and April and in October through December.

The fourth most abundant rotifer taxon was the genus *Keratella* (Figure 5-6). This genus was most abundant upstream of the entrapment zone and least abundant downstream from the entrapment zone. Except for 2000, *Keratella* abundance upstream of the entrapment zone peaked in April, and then gradually declined to its lowest value in December. In June 2000, there was a sharp drop in abundance with a gradual recovery to normal levels by September. In the entrapment zone, *Keratella* abundance was highest from February through May and October through December, and this rotifer was usually absent from June through August. *Keratella* was not found downstream from the entrapment zone during most of 1997. By October 1997, *Keratella* had returned to normal abundance levels. During the other three years, peak *Keratella* abundance occurred from January through April.

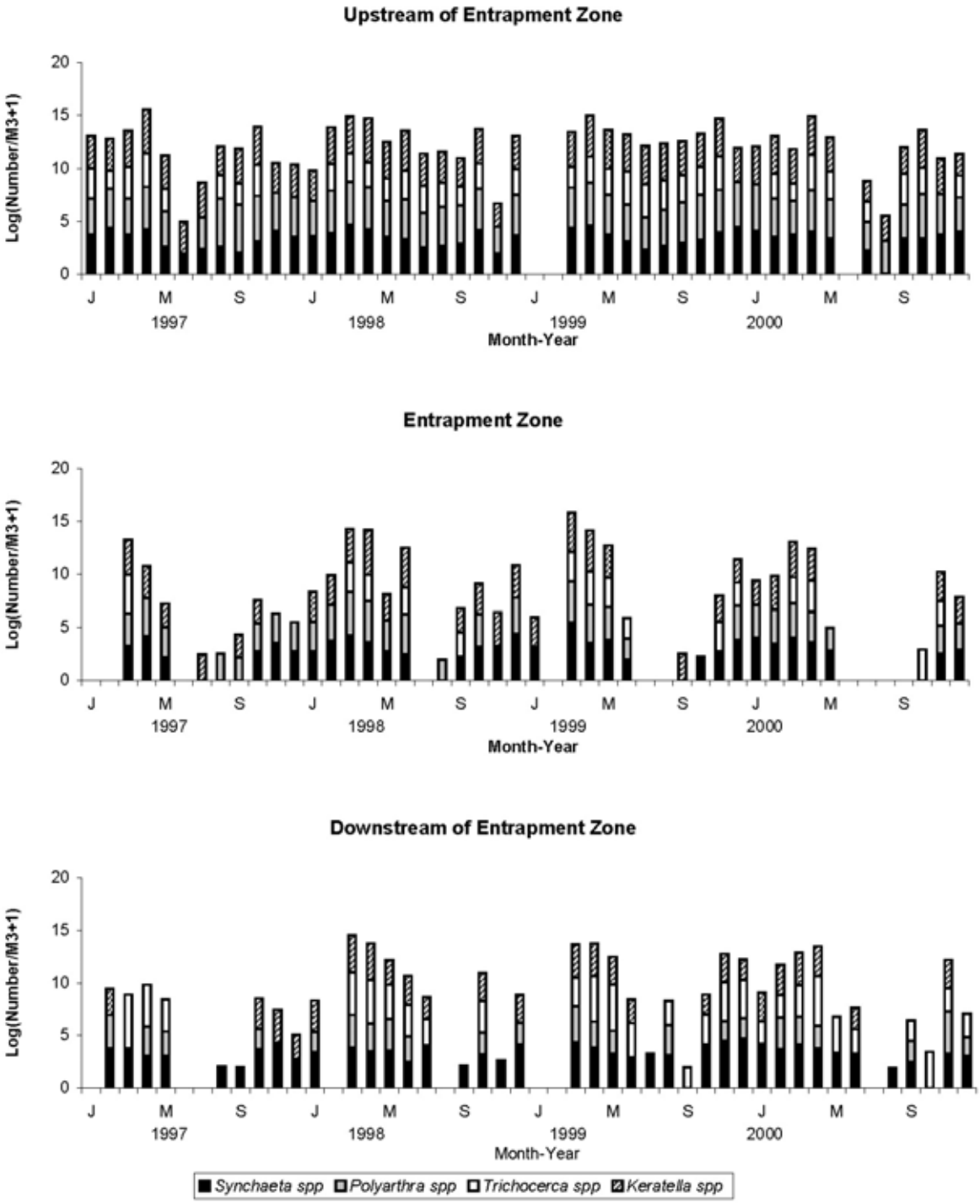


**Figure 5-6 Monthly rotifer abundance upstream from, in, and downstream from the entrapment zone, 1997-2000**